What if we built an environmental indicator and nobody came?

King County DNRP, WLRD

Science Seminar

Curtis DeGasperi

9 May 2008

SEATTLE POST-INTELLIGENCER
http://seattlepi.nwsource.com/local/208476_pugetsound19.html

State of Puget Sound troubling

Development continues to overtake cleanup efforts, report finds

Wednesday, January 19, 2005

By LISA STIFFLER
SEATTLE POST-INTELLIGENCER REPORTER

More attention is being paid to ailing Puget Sound than ever before -- but growth-related damage to the estuary's fragile environment is still outpacing governme funded cleanup efforts, according to a report released yesterday.

There are bright spots -- some polluted areas are being cleansed, invasive weeds are being repelled and the region's orca population is getting more protection, the biennial "State of the Sound" report found.

But when the Sound's overall health comes into focus, the picture is troubling.

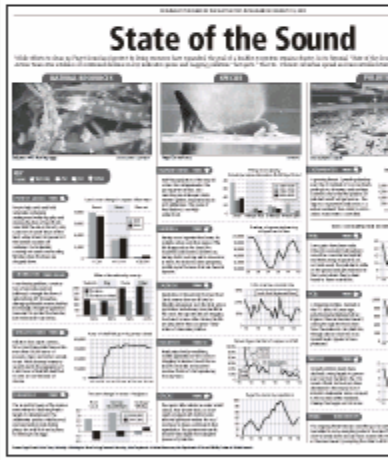
Development throughout the region is booming, and that can be bad news for marine creatures when it rains, the authors of the report, the Puget Sound Action Team, concluded.

Record volumes of unfiltered stormwater are rushing down gutters -- scouring streambeds and dumping dirt, oil, pesticides and animal waste into creeks and rivers, and ultimately the Sound.

Industrial chemicals -- even those banned decades ago -- are still hammering the ecosystem, according to the state report. Salmon runs are struggling to survive, beaches and nurturing underwater eelgrass are being lost to shoreline development, and a puzzling plunge in the seabird population continues.

There is also the fear of the unknown: the impacts of industrial flame retardants, known as PBDEs, that are used in myriad products and are making their way into the waterway.

JUST THE FACTS



A quick overview of key indicators the report.

"While we're making great progress in some areas of the Sound, the scale of those improvements and the pace is not yet equal to the pace of change and the pa decline," said Brad Ack, executive director of the Puget Sound Action Team, a government consortium that helps coordinate the state's efforts to save the Sou

"We have work to do," Gov. Christine Gregoire said in releasing the report. "This report shows the need to recommit ourselves to the important tasks of cleani Puget Sound."

ORIGINALLY PUBLISHED IN THE SEATTLE POST-INTELLIGENCER JANUARY 19, 2005

State of the Sound

While efforts to clean up Puget Sound and protect its living resources have expanded, the goal of a healthy ecosystem remains elusive. In its biennial "State of the Sound" report, the Puget Sound Action Team cites evidence of continued declines in key indicator species and nagging pollution "hot spots." The No. 1 threat: suburban sprawl and uncontrolled stormwater runoff.

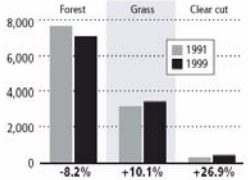
NATURAL RESOURCES

Eelgrass with herring eggs. DAN DeLONG / SEATTLE P-I

KEY
TREND Improving Fair Poor Critical

FOREST LANDS TREND:

Forests help catch and hold rainwater, recharging underground water supplies and slowing the flow of runoff into rivers and the sea. In forests, only 1 percent of runoff flows off the land, while at least 30 percent of the rainfall cascades off roadways and sidewalks, scouring out creeks and eroding hillsides when the trees are chopped down.

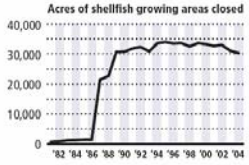


SHORELINES TREND: UNCLEAR

A continuing problem, construction of concrete and rock bulkheads strangle the flow of replenishing dirt to beaches, damaging valuable marine habitat. Increasingly stringent regulations are meant to protect the beaches, but enforcement can be lax.

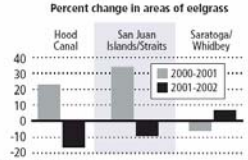
SHELLFISH BEDS TREND:

Pollution from septic systems, farms and stormwater have made more than 30,000 acres of mussels, clams and oysters unsafe to eat. While cleanup measures recently led to the reopening of 2,900 acres of shellfish beds but 18 sites are on the brink of closure.



EELGRASS TREND:

This important piece of the marine environment is declining thanks largely to development. The underwater prairies stabilize mud and sand and provide hiding places for small fish and a place for herring to lay eggs.

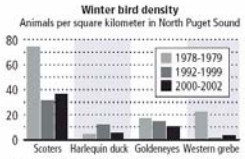


SPECIES

Puget Sound orca. AP PHOTO

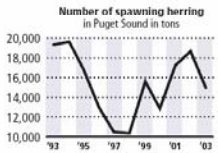
MARINE BIRDS TREND:

Half the population of the Sound's scoters has disappeared in the past quarter-century. Also vanishing are Harlequin ducks, Western grebes, long-tailed ducks and goldeneyes. The cause of their decline is not fully understood.



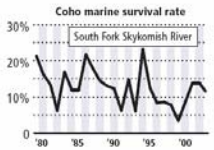
HERRING TREND:

Herring are an important food source for seabirds, salmon and other species. If the fish disappear from the Sound, the ecosystem could unravel, scientists say. Herring stocks are doing well in some areas; in others, the decline has been precipitous, possibly in part because of oil and chemical exposure.



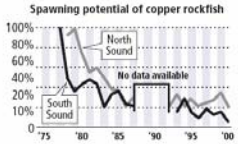
SALMON TREND:

Populations of chinook, bull trout and Hood Canal summer chum are all listed as federally endangered, and other local salmon populations are declining. Once plentiful in the Sound, the migratory fish are struggling to rebound. In some urban streams, the fish are dying before they can spawn – likely victims of stormwater pollution.



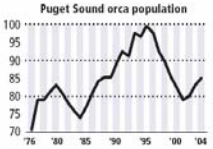
ROCKFISH TREND: NA

Nearly wiped out by overfishing, rockfish populations in the Sound are struggling to rebound. Scientists now know that rockfish are long-lived creatures that don't start reproducing for many years.



ORCAS TREND:

The region's killer whales are under assault. Salmon, their favorite food, is in short supply compared with historic levels. Industrial pollutants weaken the orcas' resistance to disease and diminish their reproduction. The government recently declared them eligible for Endangered Species Act protection.

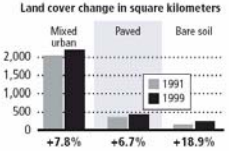


POLLUTION

Stormwater runoff. PAUL JOSEPH BROWN/P-I

STORMWATER TREND:

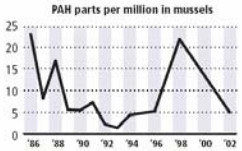
A growing threat. Sprawling development has translated in to more streets, parking lots, driveways and rooftops. Scientists worry that the problem of polluted runoff will get worse – the region is expected to balloon by 1.4 million residents from 2000 to 2025 – unless stormwater is controlled.



TOXIC CONTAMINATION IN MUSSELS FROM ELLIOTT BAY

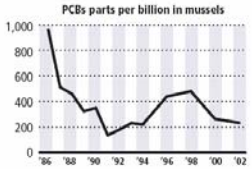
PAHs TREND:

Some gains have been made. Polycyclic aromatic hydrocarbons come from creosote and asphalt, and the burning of gasoline, oil, coal and wood. The pollutants settle on the ground and get washed into the Sound, where they've been found to harm marine life.



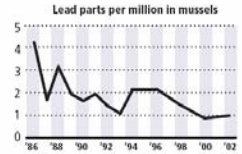
PCBs TREND:

A lingering problem. Banned in the U.S. about 30 years ago, polychlorinated biphenyl ethers linger in the marine environment, cycling through the food chain from the sediment, into plankton, through salmon and into orcas. Overall levels appear to have plateaued.



METALS TREND:

Overall pollution levels have declined, owing largely to government controls started in the '70s. Levels of lead and mercury have decreased in the Sound, but of 400,000 underwater acres surveyed, 5,700 exceed safety standards. Cleanup has begun on 530 acres.



PBDEs TREND: UNKNOWN

This ongoing threat remains something of a mystery. Polybrominated diphenyl ethers are added to many everyday products to make them fire-retardant. Like PCBs, they're slow to break down and can harm marine life. PBDE levels are believed to be increasing in the environment, prompting the state to draft an anti-pollution strategy.

Sources: Puget Sound Action Team, University of Washington Urban Ecology Research Laboratory, state Department of Natural Resources, state Department of Fish and Wildlife, Center for Whale Research

SEATTLE POST-INTELLIGENCER

PugetSoundPartnership

our sound, our community, our chance

OUR GIFT.

ARE WE LOSING OUR CHANCE TO PASS IT ON?

Home
Partnership Information
Action Agenda Center
Leadership Council
Ecosystem Coordination Board
Science Panel
Around the Sound

Not visible from a ferry deck, and hidden from postcard views, are signs of trouble in Puget Sound. Commercial shellfish beds are closed because the clams, mussels and oysters are *not safe to eat*. Some beaches are not safe for swimming because they are so *contaminated with bacteria*. In Hood Canal, there are *dead zones* – areas without enough oxygen to support marine life. Our cultural totems – salmon and orcas – and other wildlife are on life support.

These signs of trouble are increasing, and the window to turn things around is rapidly closing. >>learn more

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Action Agenda: Our Roadmap to Restoring the Sound

Across the Puget Sound region, the Puget Sound Partnership is mobilizing communities, agencies and organizations to work together to create a comprehensive Action Agenda to restore Puget Sound.

February 27th, 2008
Whidbey Basin Action Area Public Meeting

05.02.08 Video presentations from the topic forum meetings are now available. TVW also visited the May 25 Water Quality Topic Forum. Their videos are being broadcast on local TVW stations and are available online.

04.14.08 Topic forum papers are now available for review. Please join our online discussion forums to discuss each of the five topic forum papers posted today.

>>Visit the Action Agenda Center

You can share this video.

Partnership Ecosystem Goals, Strategies and Outcomes

VISION

↓

Ecosystem Goals

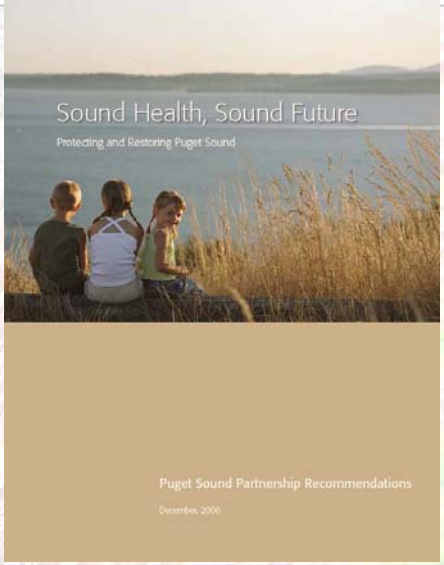
Species and Food-Web	Habitat	Water Quality	Freshwater Quantity	Human Health and Well-being

Measurable outcomes and benchmarks for each goal

↓

Strategies

Actions and measurable outcomes for each strategy



Narrative goals have been identified for Ecosystem components

- Species and food webs
- Habitat
- Water quality
- Water quantity
- Human health
- Human well being

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GALAXY THEATRES MOUSE OVER FOR MOVIE

Numbers Can Tell a Story About Puget Sound

By Christopher Dunagan (Contact)
Sunday, February 10, 2008

LACEY

A team of scientists is trying to paint a picture of Puget Sound with numbers.

The numbers, called "ecosystem indicators," might include concentrations of toxic chemicals, populations of wildlife or possibly the extent of degraded habitat. Taken together, these numbers will describe the health of Puget Sound and tell whether the problems are getting better or worse over time.

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January 23, 2007

INTERAGENCY EFFORT TO SELECT ENVIRONMENTAL INDICATORS FOR THE ACTION AGENDA OF THE PUGET SOUND PARTNERSHIP

SCOPE, OBJECTIVES AND APPROACH
NOAA-WDFW Inter-agency Personnel Agreement (IPA)

Background

In July 2007 the Puget Sound Partnership (Partnership) was formed (ESSB 5372), with a mandate to create a healthy Puget Sound ecosystem by 2020 by fulfilling 6 specific goals:

- Fresh and marine waters and sediments of a sufficient quality so that the waters in the region are safe for drinking, swimming, shellfish harvest and consumption, and other human uses and enjoyment, and are not harmful to the native marine mammals, fish, birds, and shellfish of the region.

- An ecosystem that is supported by ground water levels as well as rivers and stream flow levels sufficient to sustain people, fish, and wildlife, and the natural functions of the environment.

- A healthy Puget Sound where freshwater, estuary, nearshore, marine, and upland habitats are protected, restored and sustained.

- Healthy and sustaining populations of native species in Puget Sound, including a robust food web.

- A healthy human population supported by a healthy Puget Sound that is not threatened by changes in the ecosystem.

- A quality of human life that is sustained by a functioning Puget Sound ecosystem

Steering Committee

Name	Affiliation
Robert Duff	Department of Ecology
David Hartley	Northwest Hydraulics
Ken Currens	Northwest Indian Fisheries Commission
Joe Gaydos	SeaDoc Society
Tom Mumford	Department of Natural Resources
Mark Plummer	NOAA NWFSC
Michael Rylko	US EPA
David St. John	KC Department of Natural Resources and Parks
Mary Mahaffy	US Fish and Wildlife Service
Bruce Crawford	WA State Recreation and Conservation Office

Technical Working Group Representation

City of Seattle
Department of Ecology
King County Department of Natural Resources
NOAA -NWFSC
Northwest Indian Fish Commission
People for Puget Sound
Sustainable Seattle
Swinomish Tribe
The Nature Conservancy
U.S. Geological Survey
University of Washington
US Fish & Wildlife Service
Washington Department of Ecology
Washington Department of Fish and Wildlife
Washington Department of Health
Washington Department of Natural Resource
Washington Dept of Fish and Wildlife
Washington State Department of Ecology

What is an “Indicator”?

“…a sign or signal that relays a complex message, potentially from numerous sources, in a simplified and useful manner. An ecological indicator is defined…as a measure, an index of measures, or a model that characterizes an ecosystem or one of its critical components. An indicator may reflect biological, chemical or physical attributes of ecological condition.”

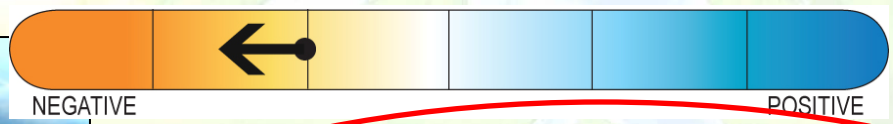
(Jackson et al., 2000)

Environmental Indicators

are attributes associated with specific ecosystem elements (e.g., water, plants, animals and people) that are used to characterize and communicate the condition of the ecosystem.

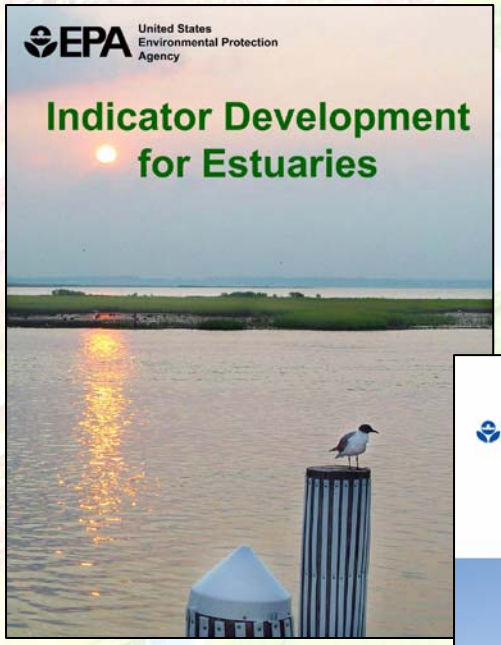
- may inform about the current or evolving state of key ecosystem elements, or
- may inform processes or mechanisms that drive ecosystem health

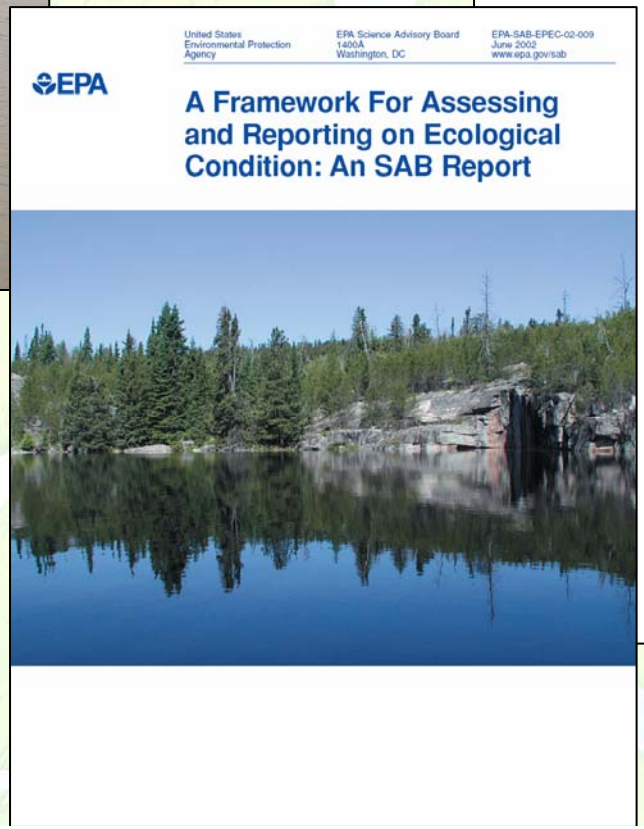
INDICATOR: **SALMON**

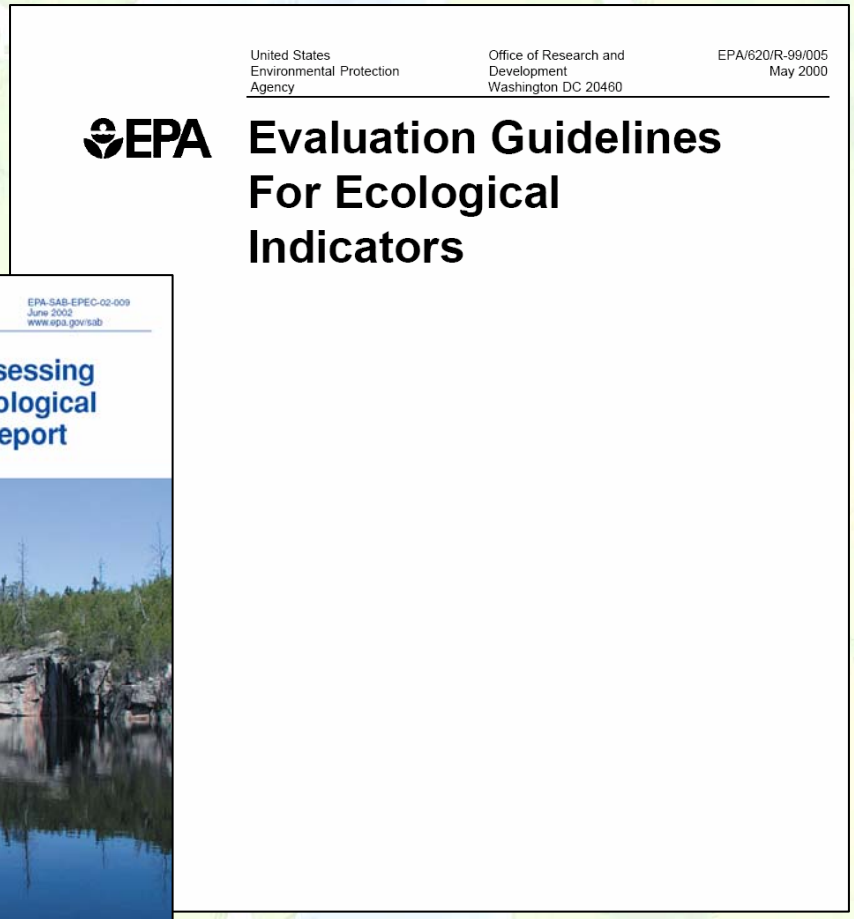


The 2006 Partnership has defined an environmental indicator as a physical, biological, or chemical measurement, statistic or value that provides a proximate gauge or evidence of, the state of the condition of Puget Sound (ESSB 5372)

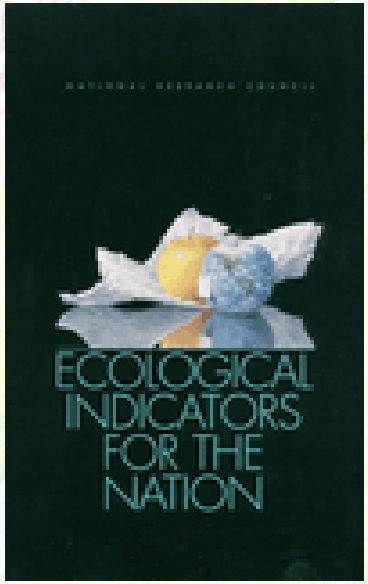
EPA Indicator Development Guidance







National Research Council 2000



ECOLOGICAL INDICATORS FOR THE NATION

Committee to Evaluate Indicators for Monitoring Aquatic and Terrestrial Environments
Board on Environmental Studies and Toxicology
Water Science and Technology Board
Commission on Geosciences, Environment, and Resources
National Research Council

NATIONAL ACADEMY PRESS
Washington, D.C.

Good environmental indicators are tools to manage ecosystems

In relation to policy-making environmental indicators are used for three major purposes:

To supply information on environmental problems, in order to enable policy-makers to assess seriousness

To support policy development and priority setting by identifying key factors that cause pressure on the environment

To assess the effects of policy responses

In addition

Environmental indicators may be used as a powerful tool to raise public awareness on environmental issues to strengthen public support for policy measures

“Good” indicators

- based on clearly defined goals and objectives and important elements in conceptual models that define key ecosystem structures and functions
- developed and selected in a logical, structured selection process that is scientifically rigorous and transparent
- must have broad regional agreement on the indicator selection criteria/framework

“Good” indicators

… must be understood and of interest to lots of people.

They must tell a story that resonates with the public and policy makers!

How do we go about selecting indicators?

- need specific goals and objectives
- need conceptual models to build a common knowledge base and identify key functions/ processes
- must develop criteria and framework for indicator selection

6 ecosystem goals by 2020

- Healthy people supported by healthy Puget Sound
- Quality of human life sustained by a healthy Puget Sound
- Puget Sound species and the web of life thrive
- Puget Sound habitat is protected and restored
- Puget Sound rivers and streams flowing at levels that support people, fish and wildlife and the environment
- Puget Sound marine and freshwater are clean

Phase 1 Provisional Indicators Tasks

1. **Develop criteria and a framework to be used for selecting environmental indicators.**

2. **Create conceptual models that define key structures and function for the six Puget Sound ecosystem components.**

3. **Identify, compile, and summarize former, current and proposed indicators for the Puget Sound ecosystem.**

4. **Select and evaluate the most suitable environmental indicators based on criteria/ framework and the conceptual models.**

Indicator Selection Guidelines

- Conceptual relevance
- Feasibility of implementation
- Response variability
- Interpretation and utility

Jackson et al.,eds. 2000. Evaluation Guidelines for Ecological Indicators. EPA/620/R-99/005. US EPA, ORD, Research Triangle Park, NC. 107 p.

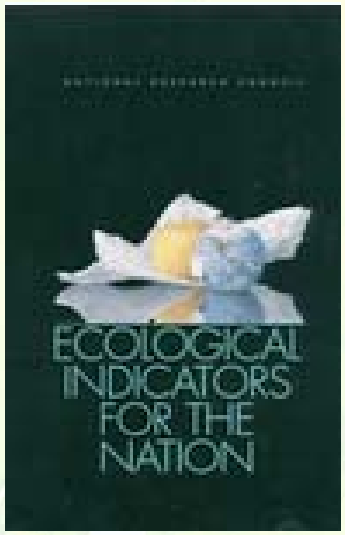
Examples of criteria

Criteria

Cost-effectiveness
Is the value of the information obtained with the indicator cost-effective

General importance
Does the indicator tell us something about major environmental changes?

Robustness
Does the indicator yield reliable and useful numbers?



Conceptual basis
Is the indicator based on a well understood conceptual model?

Reliability
Has the indicator been used previously successfully?

Skills required
Is the data collection a straightforward process?

Temporal and spatial scales
Can the indicator detect changes at appropriate temporal and spatial scales without being overwhelmed by variability ?

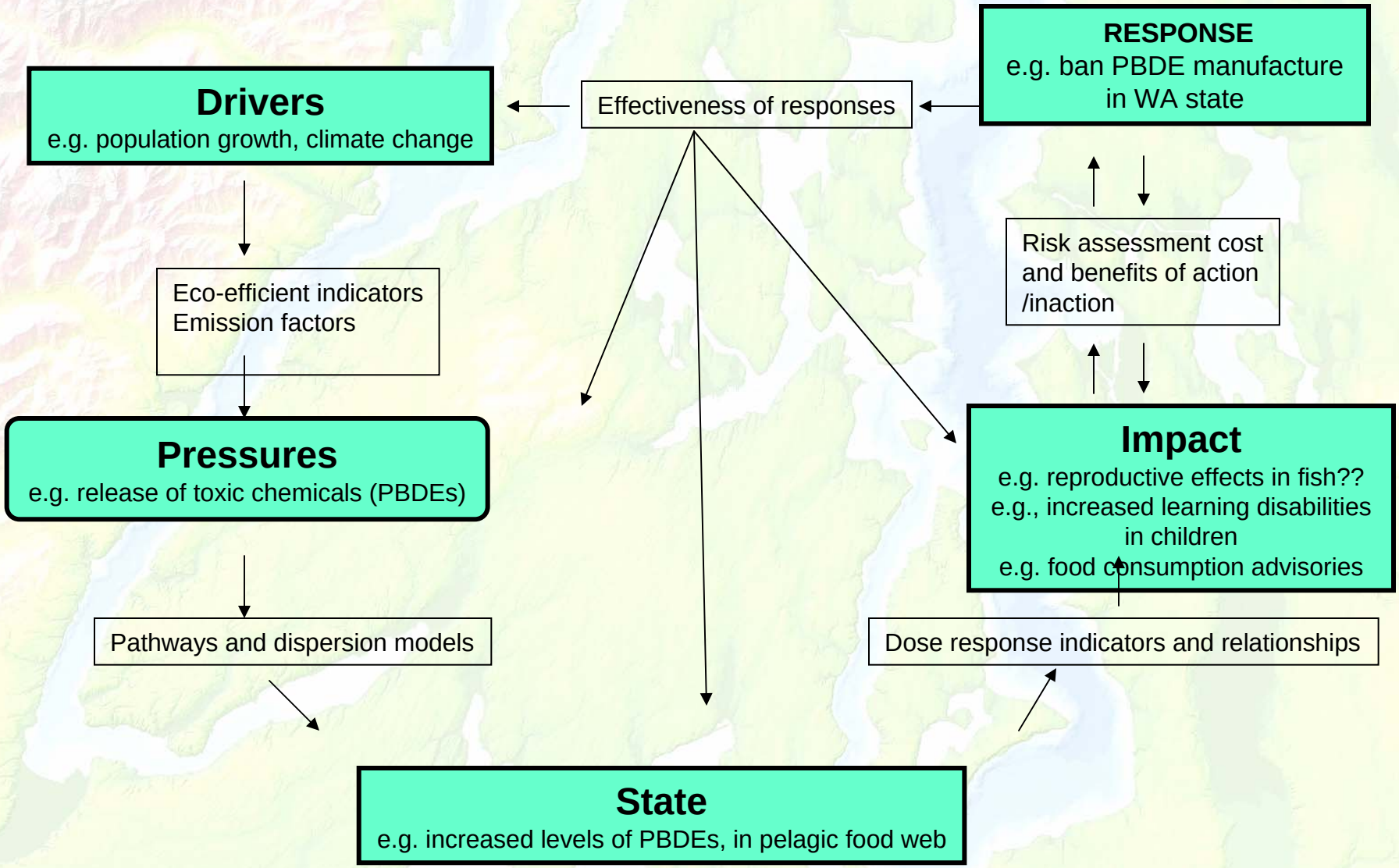
Data requirements
What kind of data is necessary to obtain reliable estimates of the indicator to be calculated?

Statistical properties
Is the indicator sensitive enough to detect changes not masked by natural variability?

What is a conceptual model?

- A conceptual model is a visual and/ or narrative explanation of how a system works or it is expected to respond (CALFED 2006).
- Useful ecological indicators are based on clear conceptual models of the structure and functioning of the ecosystems to which they apply (IMST, 1998).
- Ideally, conceptual models detail the assumed relationships between composition, structure patterns and processes relevant to the ecosystem being monitored.

Conceptual Model: DPSIR

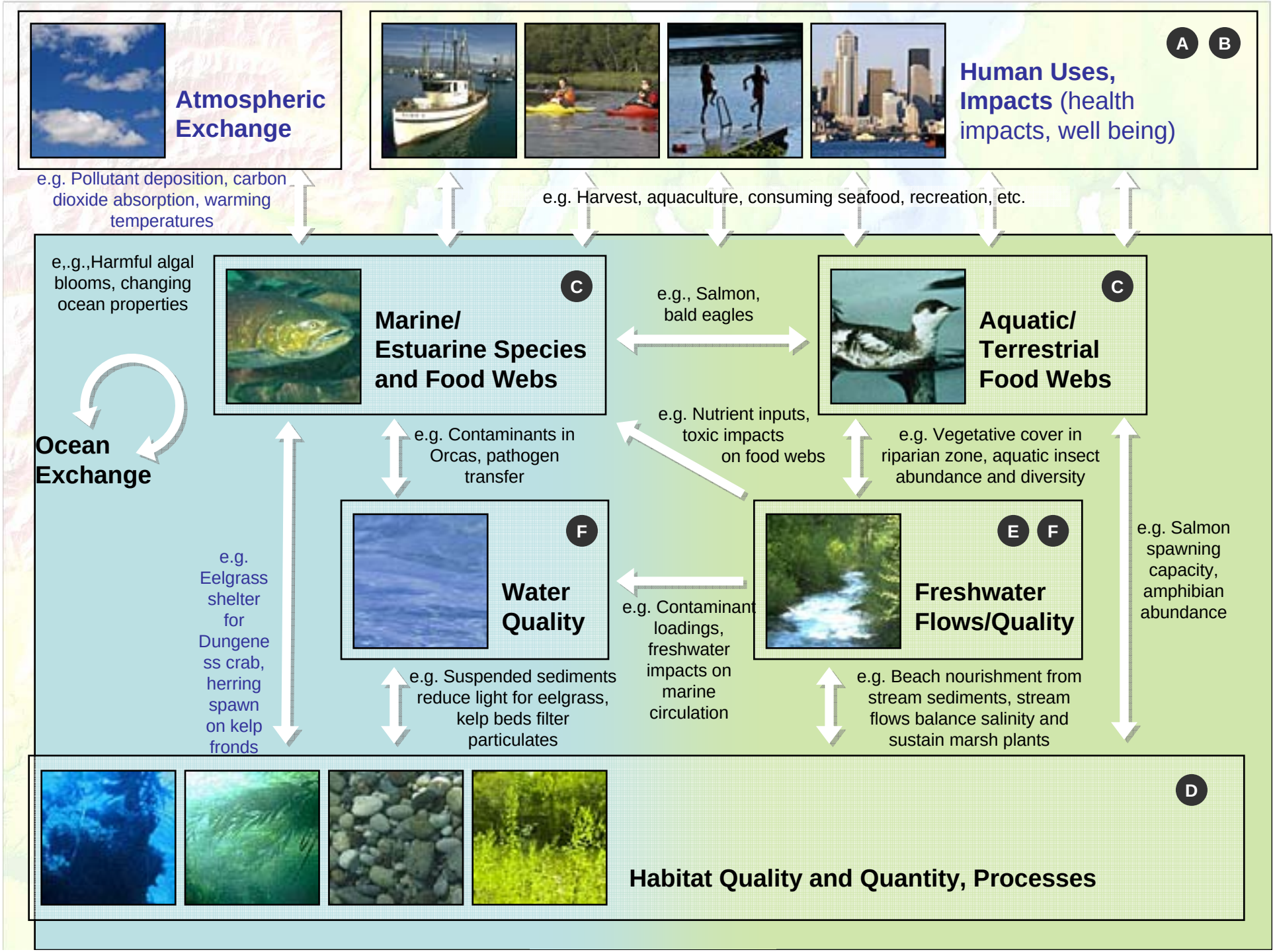


Rationale for using conceptual models

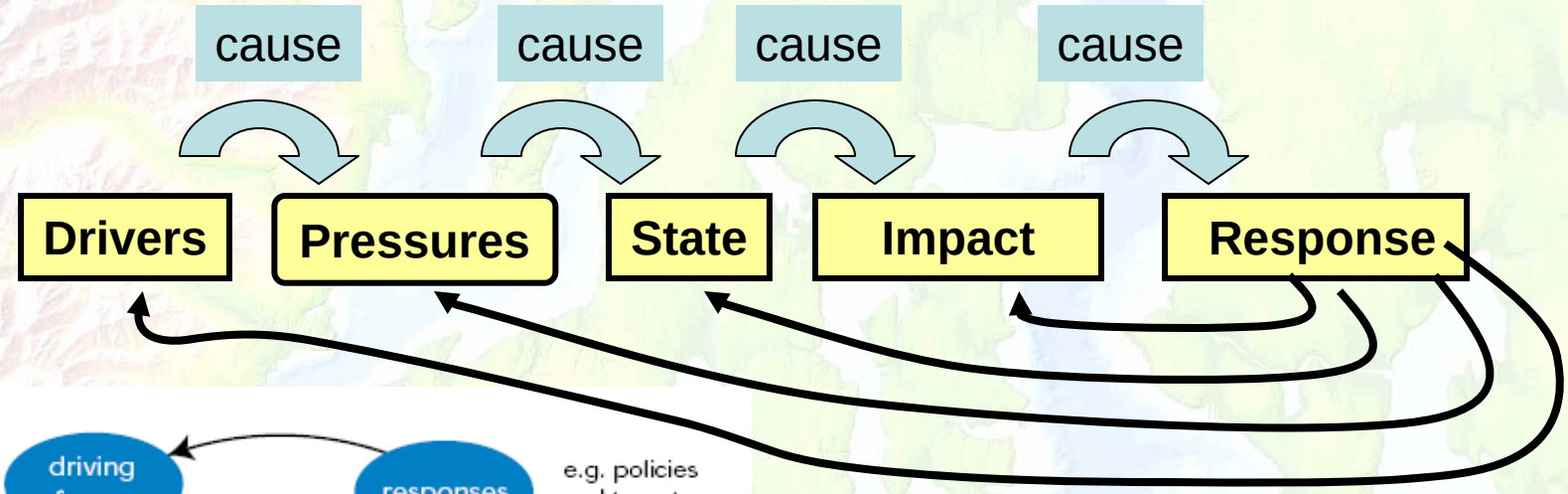
- Serves as common knowledge base for scientist.
- To elucidate causal links between indicators within the Puget Sound ecosystem components.
- Serves as a tool of communication with non-scientists.

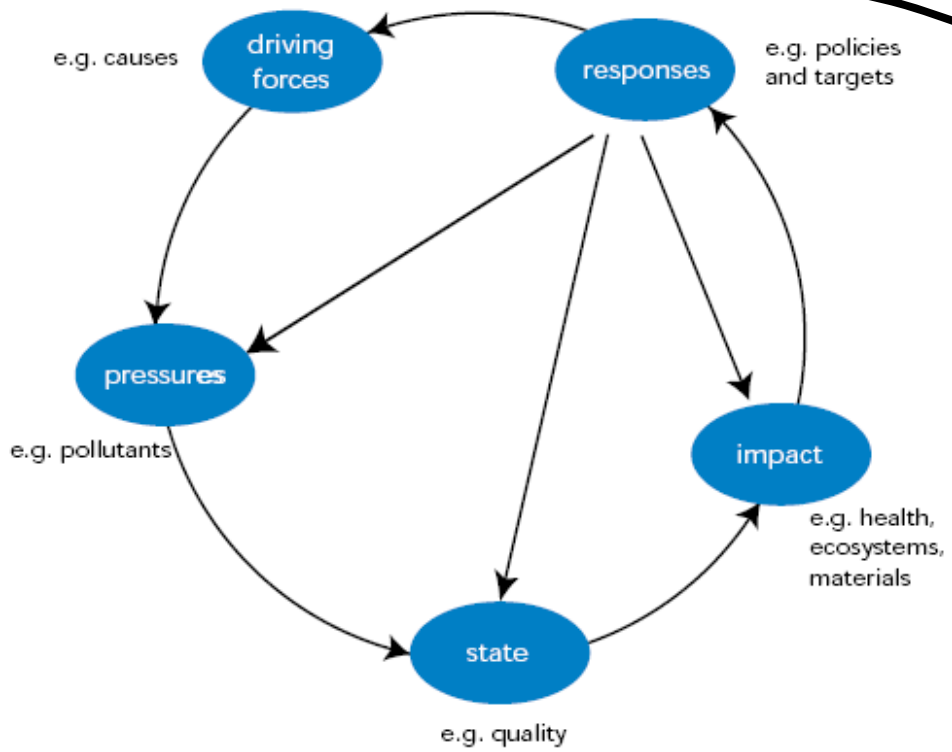
LIST OF CONCEPTIAL MODELS TO BE DEVELOPED

Ecosystem Component	Ecosystem Sub-Componet	Marine Areas	Freshwater Areas	Terrestrial Areas
Water Quality	Toxics	x	x	
	Nutrients	x	x	
	Pathogens	x	x	
Water Quantity			x	
Species		x	x	x
Habitats		x	x	x
Human Health		toxics, pathogen, nutrients plus connections		
Human Well Being		show as connections to other CM ?		


Atmospheric Exchange
A
B
Human Uses, Impacts (health impacts, well being)
e.g. Pollutant deposition, carbon dioxide absorption, warming temperatures
e.g. Harvest, aquaculture, consuming seafood, recreation, etc.
e,.g.,Harmful algal blooms, changing ocean properties
C
Marine/ Estuarine Species and Food Webs
e.g., Salmon, bald eagles
C
Aquatic/ Terrestrial Food Webs
Ocean Exchange
e.g. Contaminants in Orcas, pathogen transfer
e.g. Nutrient inputs, toxic impacts on food webs
e.g. Vegetative cover in riparian zone, aquatic insect abundance and diversity
F
Water Quality
E
F
Freshwater Flows/Quality
e.g. Salmon spawning capacity, amphibian abundance
e.g. Eelgrass shelter for Dungeness crab, herring spawn on kelp fronds
e.g. Contaminant loadings, freshwater impacts on marine circulation
e.g. Suspended sediments reduce light for eelgrass, kelp beds filter particulates
e.g. Beach nourishment from stream sediments, stream flows balance salinity and sustain marsh plants
D
Habitat Quality and Quantity, Processes

DPSIR FRAMEWORK

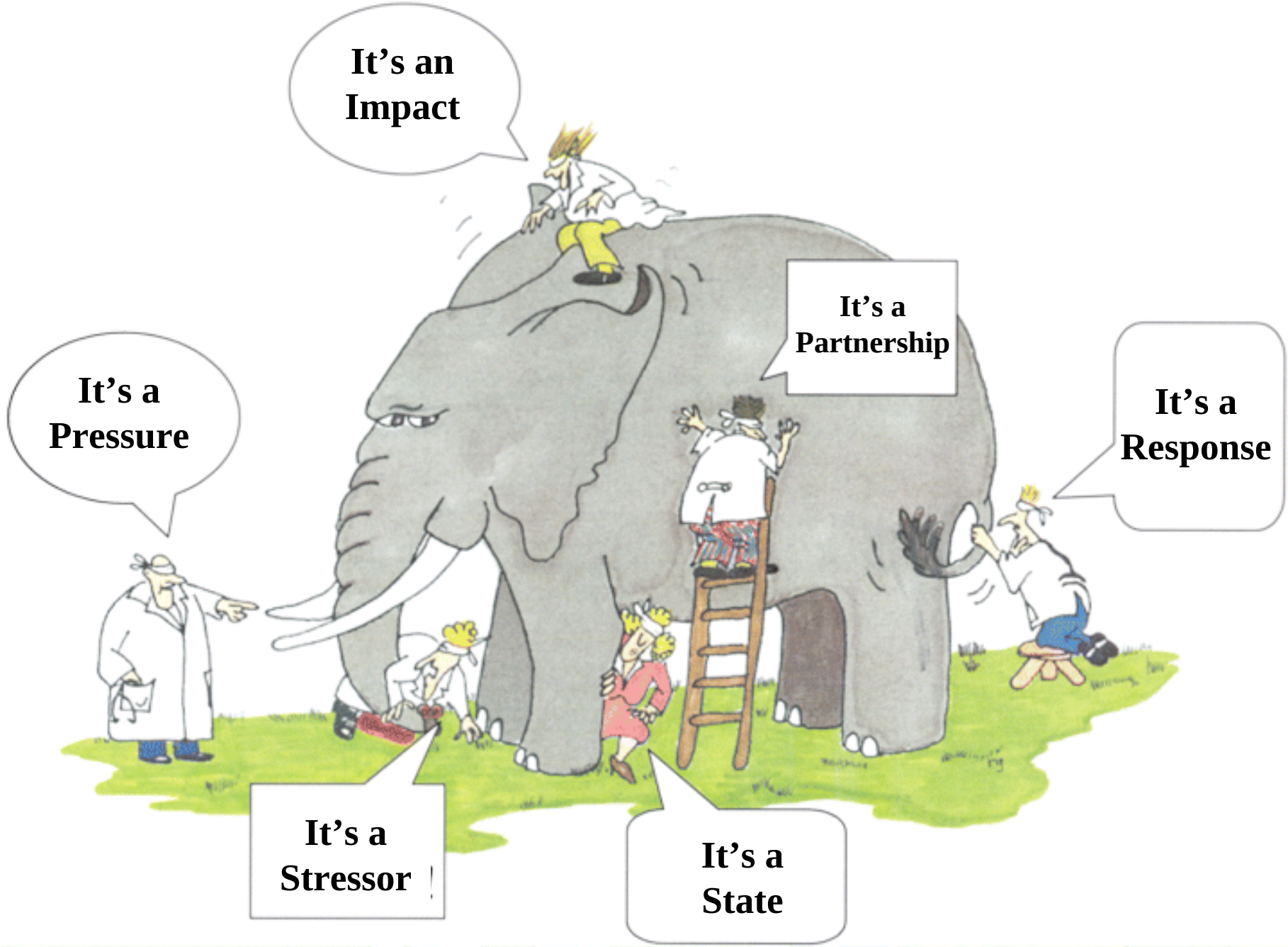


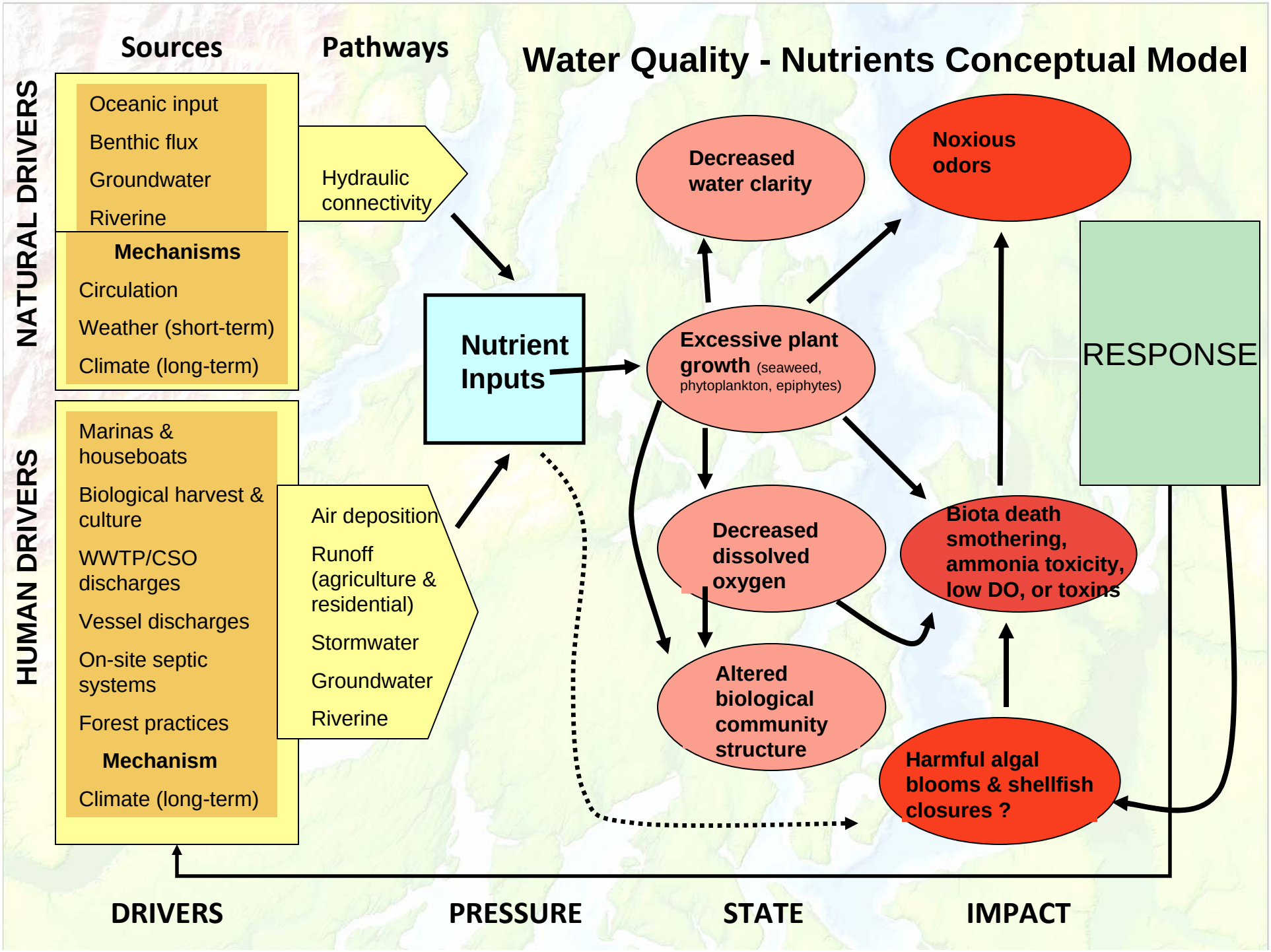


Source: EEA

DPSIR definitions

Reference	DRIVER	PRESSURE	STATE	IMPACT	RESPONSE
EEA	Describe the social, demographic and economic developments in societies and changes in life styles, levels of consumption and production patterns.	Pressures exerted by society are transported and transformed in a variety of natural processes to manifest themselves in changes in environmental conditions.	Describes the quantity and quality of physical biological, and chemical phenomena in a certain area.	Describes impacts on the social and economic functions on the environment.	Refer to responses by groups and individuals in society as well as government attempts to prevent, compensate or adapt to changes in the state of the environment.
Bowen, 2003	Describe large scale socio-economic conditions or sectoral trends such as land use and land cover and development in industry sectors.	Describe natural processes and the results of human activities that impact, stress, or pose a threat to environmental quality	Address the state of the environment, the quality and quantity of natural resources, and the state of human and ecological health.	Defined as the discrete measured changes in social benefit values linked to environmental conditions.	Include individual and collective actions to halt, mitigate, adapt to, or prevent damage to the environment.
Pirrone et al.2005	processes and anthropogenic activities (production, consumption, recreation, etc) able to cause pressures.	direct stresses, deriving from the anthropogenic system and affecting the natural environment.	reflects the environmental conditions of natural systems.	is the measure of the effects due to changes in the state of environmental system	Is the evaluations of actions oriented to solve environmental problems in terms of management strategies.


It's an Impact
It's a Partnership
It's a Pressure
It's a Response
It's a Stressor
It's a State


Water Quality - Nutrients Conceptual Model
Sources
Pathways
NATURAL DRIVERS
Oceanic input
Benthic flux
Groundwater
Riverine
Mechanisms
Circulation
Weather (short-term)
Climate (long-term)
Hydraulic connectivity
HUMAN DRIVERS
Marinas & houseboats
Biological harvest & culture
WWTP/CSO discharges
Vessel discharges
On-site septic systems
Forest practices
Mechanism
Climate (long-term)
Air deposition
Runoff (agriculture & residential)
Stormwater
Groundwater
Riverine
Nutrient Inputs
Excessive plant growth (seaweed, phytoplankton, epiphytes)
Decreased water clarity
Noxious odors
Decreased dissolved oxygen
Altered biological community structure
Biota death smothering, ammonia toxicity, low DO, or toxins
Harmful algal blooms & shellfish closures ?
RESPONSE
DRIVERS
PRESSURE
STATE
IMPACT

1. Indicator list of lists version.4

Document title	Author	Year published	Page #	Indicator	Where developed	PDF Posted/location online
Puget Sound Update: ninth report of the Puget Sound assessment and monitoring program	Puget Sound Action team	2007			Puget Sound	http://www.psat.wa.gov/Publications/update_07/update07.htm Web portal folder inventory of indicators/Puget Sound Geogia Basin
Status and Trend Monitoring for Watershed Health and Salmon Recovery	Department of Ecology	2006	Page 31-46	Mostly monitoring but also contains indicators for water quality, habitat, riparian and upland and biological	Washington State streams	http://www.ecy.wa.gov/programs/eap/stsmf/ http://www.rco.wa.gov/Documents/Monitoring/Framework_Document.pdf
EPA Georgia Basin-Puget Sound Indicators	Environmental Protection Agency	2002	there is a summary report per subject on the website	different indicators on population, air quality, marine water quality, shellfish	Puget Sound/ Georgia Basin ecosystem indicators	http://www.epa.gov/region10/psgb/indicators/

1. Indicator list of lists version.4

Document title	Author	Year published	Page #	Indicator	Where developed	PDF Posted/location online
Pug ninth Sou mo						w.psat.w plications 07/update htm tal folder tory of rs/Puget Geogia sin
S Wat Sa						w.ecy.w grams/ea smf/ ww.rco.w cuments/ ng/Frame ocument. df
EPA Georgia Basin-Puget Sound Indicators	Environmental Protection Agency	2002	summary report per subject on the website	quality, marine water quality, shellfish	Georgia Basin ecosystem indicators	http://www.epa.gov/region10/psgb/indicators/

A total of 100 documents were collected…

2. Indicators compiled by PSP contractor

Master Indicator	#	Indicator Name (used in Document)	Indicator Description	Ecosystem Component (Topic Forum)	PSP Outcome	Ecosystem Habitat Type
Fish - Toxicity	4	**Toxics in Chinook and Coho salmon**	Concentrations of toxic pollutants (PCBs, PBDEs) in chinook and coho tissue	Water Quality Human Health	WQL-1 HH-1	Nearshore & estuarine Marine deep water Freshwater (few)
Toxics in Mussels	5	**Toxics in Mussels**	Concentrations of toxic contaminants (PAHs, PCBs, mercury) in mussel tissue	Water Quality Human Health	WQL-1 HH-1	Nearshore & estuarine
Toxics in Harbor Seals	6	**Toxics in Harbor Seals**	Concentrations of toxic contaminants (PCBs, PDBE) in seal tissue	Water Quality--T	WQL-1	Nearshore & estuarine
Fish - Toxicity	7	**Liver Disease in English sole**	Average risk for English sole 1) developing liver lesions and 2) exposure to PAHs at selected locations. Data collected by WDFW, NOAA 17 years	Water Quality Human Health	WQL-1 HH-1	Marine deep water
Oil Spills	8	**Oil Spills**	Volume and number of oil spils in Puget Sound	Water Quality	WQL-1	Marine deep water Nearshore & estuarine

2. Indicators compiled by PSP contractor

N		Indicator Name		Ecosystem		Ecosystem Habitat Type
Fish -						ore & estuarine Marine deep water Freshwater few)
Toxics						ore & estuarine
Toxics						ore & estuarine
Fish -						deep water
Oil Spills	8	**Oil Spills**	Volume and number of oil spils in Puget Sound	Water Quality	WQL-1	Marine deep water Nearshore & estuarine

Individual Indicators listed for 69 of 104 documents…

Approaches for Indicator Selection

- **Historical Use**
- **Criteria** - applied to individual indicators
- **Hierarchical Evaluation Guidelines** - provides a framework to ask the right questions in a structured a manner (e.g. Kurtz et al. 2001)
- **DPSIR**- criteria applied to a <u>set of indicators</u> in causal chain
- **eDPSIR** - criteria applied to multiple causal chains (e.g. Niemeijer and de Groot 2008)

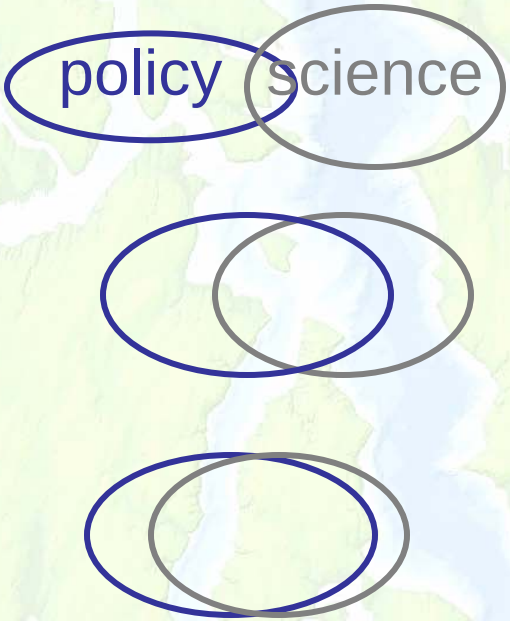
Phase 2+

- Continue dialogue between policy and science
- Using the criteria and framework developed in Phase 1, refine indicator selection, add new indicators, create synthetic indicators as needed.
- Refine conceptual models.
- Add thresholds to Indicators
- Use Integrated Ecosystem Assessment (IEA) to model management scenarios
- Trade-offs must happen between goals

Indicator selection involves iterative dialogue between policy and science

Leadership Council
Ecosystem Coordination Board
General Public

Indicators SC and TWG
Science Panel
Scientific Community



Policy-Science interface

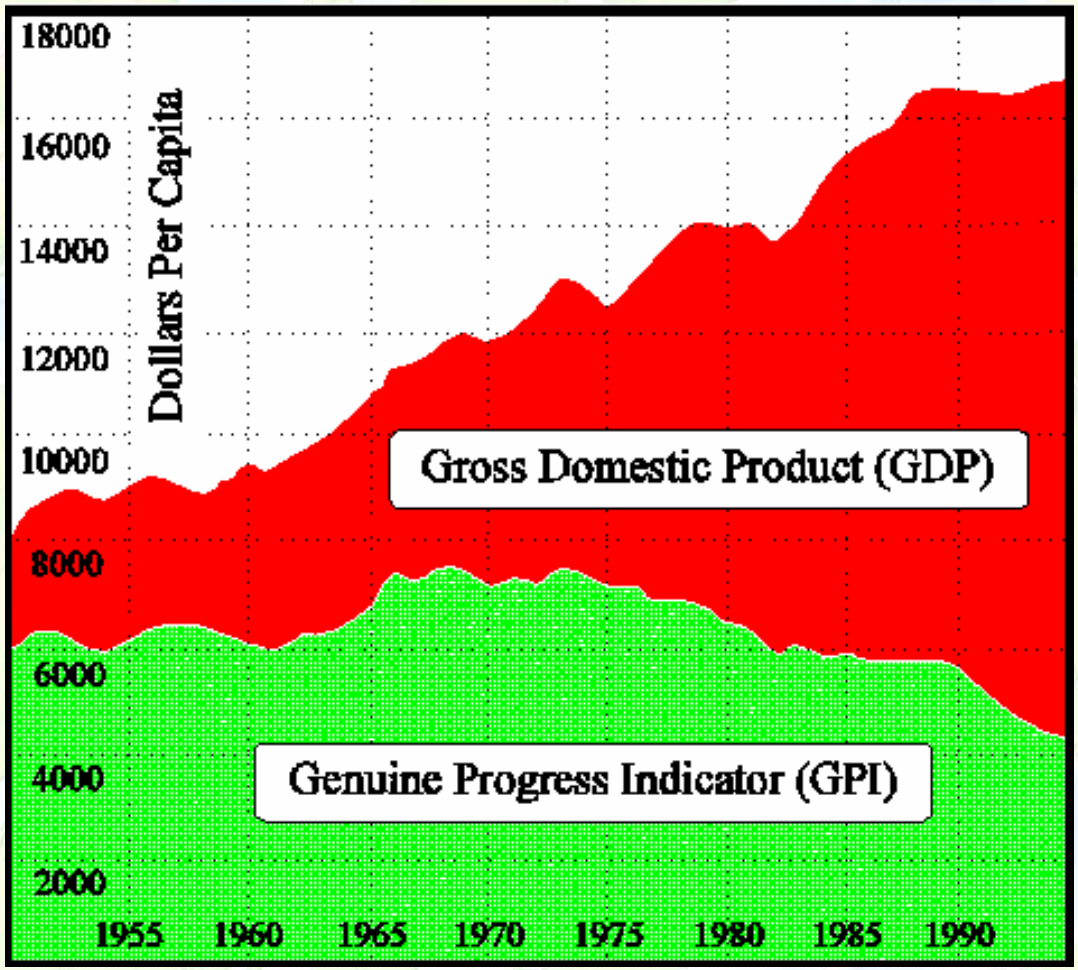
State of the Gulf (of Maine)

- "Lessons Learned" by Developers of Environmental Indicators (2003)
  - 2 to 5 year process ($100 - $200k + donated time)
  - Considered existing data or didn't
  - Initial lists ranged from 100 to 800 candidate indicators and final lists from 6 to 100
  - Indicators and workgroups divided into sub-groups based on issues (water quality, biota, land use)
  - Data and resource limitations for sampling common
  - Difficult to match indicators to target audience
  - Regrets that wider range of individual not consulted to make indicators more useful in management and policy-decision making

http://www.gulfofmainesummit.org/docs/Lessons_Learned_Report.pdf

State of the Gulf (of Maine)

- "Lessons Learned" by Developers of Environmental Indicators (2003)
  - Few interviewees could cite any specific instances where indicators or reports were explicitly used for policy or management decisions

http://www.gulfofmainesummit.org/docs/Lessons_Learned_Report.pdf

Economic Indicators